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THE SAN FRANCISCO BAY AREA MASS RAPID TRANSIT STUDY

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CITY PLANNING DIVISION

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THE SAN FRANCISCO BAY AREA MASS RAPID TRANSIT STUDY[1]

R.F. Ziegenfelder,[2] M. ASCE

For over a year now, our firm has been engaged in a study and survey of the nine counties comprising the San Francisco Bay Area. We are charged with the responsibility of providing a comprehensive report on the feasibility of inter-urban mass rapid transit for this area. Since August of 1953 we have been studying, analysing, projecting and delineating all factors concerned with transportation in this metropolitan area of some 7400 square miles. This is February of 1955, and the question certainly arises as to what have we developed on this job during that time. In the course of this short discussion, I hope to be able to convey to you the concepts that we have developed and some of the findings of our analysis.

One of the first major recognitions of mass rapid transit problems in the Bay Area was the passage by the Legislature and the approval by the Governor, in 1949, of the basic enabling legislation permitting the establishment of a nine-county rapid transit district. This Act has never been utilized by the communities, but in 1951, the Act was amended to create the San Francisco Bay Area Rapid Transit Commission. The Commission was assigned the specific task of studying and investigating "rapid transit problems in the San Francisco Bay Area" and given the duty of "developing a master, coordinated rapid transit plan, including an estimate of the cost of construction and of necessary lands, equipment and facilities." The Commission took the first step in carrying out this assignment, when in January of 1953 their preliminary report called for a financing program of $750,000 for the purpose of studying the feasibility of rapjd transit. This report stated: "that a satisfactory solution to the transit problem in the Bay Area cannot be reached by building highways and facilities for automobile transportation alone; that the solution can be reached only through evolving a satisfactory system of mass rapid transit developed on the premise of moving people—not moving cars." The Legislature and Governor Warren concurred in this proposal and approved an appropriation of $400,000 contingent on the raising of $350,000 on a pro-rata basis by the nine counties.

We were selected as consultants to the Commission in August of 1953 and immediately started our two-year assignment. This task consists of four major responsibilities:

1) To prepare an over-all regional plan for the Bay Area including future population projections and detail economic studies;

2) To conduct origin and destination studies of inter-urban vehicular and transit passengers;

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1. ASCE San Diego, Calif., Feb. 10, 1955.
2. Partner, Parsons, Brinckerhoff, Hall & Macdonald, San Francisco, Calif.

3) To prepare an over-all regional transit plan designed for stage construction with estimates of timing for each stage;

4) To prepare financial analyses and construction costs and revenue estimates for the initial stage of construction.

In the course of this unique engineering study some basic concepts of rapid transit in urban areas have evolved. The fundamental purpose of our job as we conceive it is that of finding a solution to the traffic jams that presently characterize the modern-day pattern of private passenger car and common carrier movements on streets and highways within the Bay Region metropolitan area.

Our task, therefore, is to appraise inter-urban mass rapid transit in terms of potential effectiveness as an instrument to meet this responsibility. To do this, we must determine the physical extent and the degree of service, comfort and convenience of a transit system that would be necessary to achieve our objective of relieving surface traffic jams. Also, a forecast of financial performance of such a system must be made in relation to capital and operating costs and finally an evaluation of the results in comparison with the alternate solution of extensive highway and parking lot expansion.

I specifically include the expansion of parking facilities as an integral part of an alternate solution in order to emphasize an oft-forgotten point that the average number of passengers on one commuting train would—if each elected instead to drive his own automobile—require approximately 7 acres of parking lot by way of terminal facility.

It is quite clear that any understanding of our problem must begin with a knowledge of the source and characteristics of the overall public demand for transportation. In the first place, it is helpful to classify travelers in three fundamental categories:

1) Those to whom a private car is not effectively available and who must therefore use public transportation;

2) Those to whom a private car is not only available but for whom no other transportation will do. Among these, for instance, are doctors, traveling salesmen, real estate appraisers, repair men—the entire category, in fact, of those for whom the sustained use of the private automobile is essential in their business. In this category, too, we must include any citizen who is traveling for recreation and considers his car essential for continued use at the end of his principal journey.

3) Those to whom a private car is available throughout the day, whose requirement for transportation is a simple round trip, such as home-to-work-to-home or home-to-shopping-to-home, and who therefore, would have the option of using either their private cars for transportation or public transportation for all or part of their trip, if available and convenient.

For that second group of those who must use their private car, there is well underway, as part of the overall solution to transportation problems, the very large regional freeway program in the Bay Area. But, even with this fine system of regional freeways, there is hardly a lessening of the daily highway congestion, particularly during the weekday periods of the morning and evening rush hours.

The major contribution to this nerve-wracking congestion is that third group, the home-to-work and return travelers. They have the option of

private car or public transportation and, because of current transit conditions in their area they are forced or prefer to use that car despite the jams and inability to locate suitable parking facilities. From our studies we know that these travelers are causing very short, but intensive peaks, as shown in Figure 1, and that they are also the group who can be most effectively served by transit. So, approaching the existing problem with this viewpoint, we conceive of an inter-urban mass rapid transit system to attract primarily these home-to-work daily commuters and thereby considerably relieve the peak hour pressure on highways and local streets.

Functional Standards of the System

The operational standards of the rapid transit system call for the following:

1) An exclusive, grade-separated right-of-way. By operating on such a right-of-way the system is invulnerable to any surface street traffic congestion.

2) Destination stations and terminals located within convenient walking distance of major employment centers and shops. (This requirement would probably mean about a half-mile.) The design and circulation plan for parking facilities must be adequate for the demand and not interfere or induce traffic congestion at peak hours on adjacent city streets. Originating station layout must also provide for convenient transfer between the local surface distribution system and the rapid transit line.

3) Time-distance of travel as expressed in terms of over-all average speed is probably the most essential factor in this transit system. We look for a minimum average operating speed of 45 miles an hour, including station stops. The speed of a rapid transit system must approximate that of a private automobile on comparatively uncongested freeways.

4) And in keeping with the idea of diverting private automobile drivers and passengers, car design standards must be kept at the highest level with seats for all passengers, quietly operating vehicles that are comfortable and well-lighted, with good ventilation and pleasant colors. Headways must be at a minimum even during off-peak hours. These then are the fundamental concepts we are being guided by in this rapid transit study. A few words now on <u>how</u> we have conducted the study up to the present time.

Regional Planning: 1954 to 1970

In order to provide a comprehensive inventory of facts concerning the Bay Area as it exists today, our planning staff together with local planning agencies, produced initially in the spring of 1954 a compilation of current land use. This survey classified and analyzed, among other facts, the major elements of the region's present transportation system including highways, railroads, airports and seaports. The planning studies continued through a complete summary of land resources of the region which served as a basic foundation for the preparation of the regional plan of future physical development.

Along with the physical planning work, studies of past and future population and employment trends were made. The study included a complete analysis of population rate increases in the Bay Area as a whole and in each county along with the underlying causes of those increases. (See Figure 2.) Other analyses were made to evaluate the relative significance of the many factors influencing economic growth in the separate parts of the region.

All of these findings, including traffic volumes and patterns about which I will have more to say later, have been correlated to show an overall picture of the past trends, current developments and indications of future growth in the Bay Area and, in particular, how that growth will influence future transportation needs.

Origin and Destination Procedures

The second responsibility under our contract agreement with the Commission was to conduct origin and destination studies in the nine counties. The survey, which began in February of last year and was completed in April, measured the current travel requirements of people moving from place to place in the region. This data detailed origins and destinations of passenger trips, together with times, mode of travel, and purpose of the movement.

The origin and destination survey was one of the most extensive of its type ever conducted. The field work involved objectives and the development of answers not generally required heretofore from such surveys. It was based on a ten percent sampling of some 830,000 average weekday cross-cordon trips within the Bay Area. From the cordon stations around the City and County of San Francisco, we found a total of 94,000 persons travelling into and out of the city by the various modes of public transportation as compared with 284,000 people transported in private cars. In the East-Bay Metropolitan Area which is composed of ten contiguous cities, the comparable figures are 45,000 people by transit and 322,000 by highway. The higher proportion of transit riders into and out of San Francisco is accounted for by the existence of a fairly efficient rail commuter service. A generalized traffic flow map is presented in Figure 3.

The field work of the survey involved two separate operations for highway and transit interviews. Highway traffic was surveyed by operating roadside interview stations located on a series of cordon lines which intercepted all the major interurban movements within the Bay Area. Bus and rail passengers were surveyed by questionnaire cards handed out during on-board riding checks and by post-card questionnaires handed to transit patrons in stations and terminals.

All of this data was collected directly on business machine cards and then translated into mark-sense pencil-lead impressions on these cards. To our knowledge, this is the first large-scale traffic survey in which business machine cards were automatically punched from mark-sense impressions made during the course of the survey.

When all of this data had been tabulated, we then had a picture of 1954 travel patterns in the Bay Area, but the task remained to project what those patterns would be when growth reached a 1970 projected high population of 4,800,000. This was the figure developed in the population studies for use in the outline regional plan, and represents a phenomenal 60 per cent increase over 1954. This work of producing what might be called a 1970 pattern of Origin and Destination is another example of special techniques that have been applied in the course of this study.

Using the existing patterns of travel as a foundation, together with projected future patterns of population and employment distribution, a forecast of future travel movements within the nine-county area had to be constructed. Still remembering that group of commuters-to-work as our best bet for transit patrons, we separated from these 830,000 daily trips, all of the work-to-home and home-to-work trips. This breakdown included approximately 400,000 trips. Then, for each of the 23 cordon areas established by the traffic survey, projections were made of population, jobs, and employed residents.

From this information, relationships were developed between these factors, which provided a figure for the total net in-commute or net out-commute for work in each cordon area, at the 4.8 million population level. A net in-commute existed if jobs exceeded employed residents in any given section; and a net out-commute situation existed if the reverse were true. In both of these situations, the magnitude of commutation to or from work in other sections of the Bay Area could then be projected and distributed among the cordon areas according to weighted factors of job opportunity in relation to effective commute distance.

For trips other than those to or from work, estimates were projected from the relationships found by analysis of the 1954 origin and destination survey. A series of correlations were established between "work" and "other" trips generated by each of the twenty-three sections of the Bay Area.

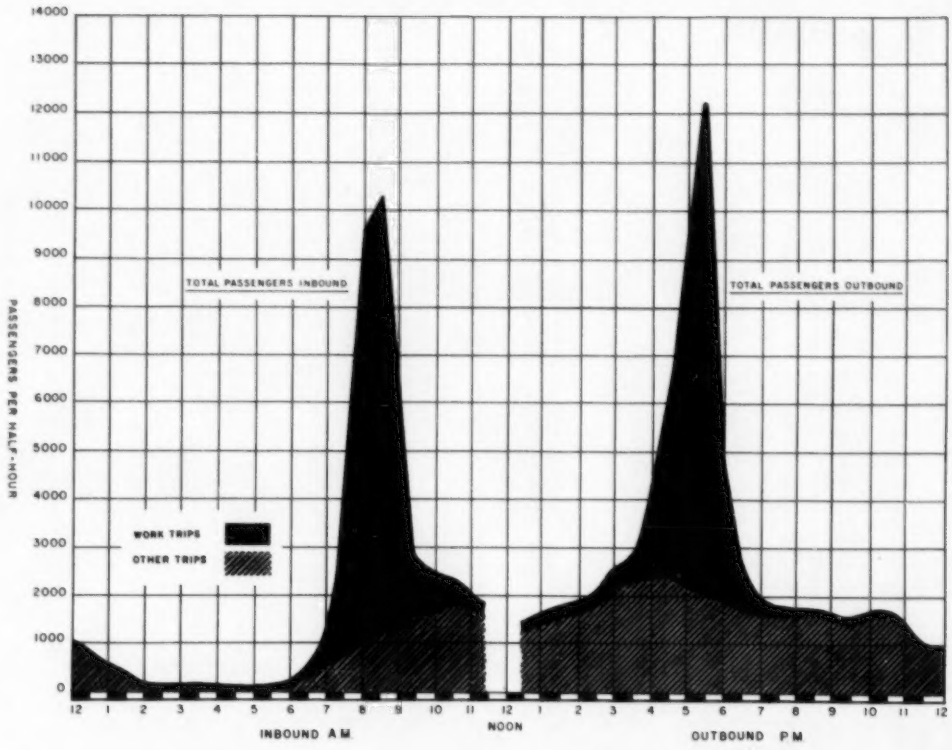
Traffic in the nine-county area was also projected from 1954 to 1962. 1962 has been assumed as the earliest possible full year of operation for the first stage of an overall rapid transit system. Using a modified interpolation process, we estimated total traffic demand for 1962, based on the 1954 survey and the projections based on the 4.8 million population.

From these projections of total transportation demand, application of tested diversion factors yielded required rapid transit passenger capacities and permitted estimates to be made of maintenance and operating costs along with operating revenues. Together with these financial analyses, we are continuing detailed engineering studies of route locations, structures, rolling stock, power requirements, signal controls, scheduling, station location and design. These engineering studies are being made concurrently for several types of transit facility.

At the present time, it is our intention to give the San Francisco Bay Area Rapid Transit Commission a finished report in June or July of this year. Following our report, the Commission will receive a study underway by Stanford Research Institute on the fiscal and organizational aspects of an authority that would build and operate any proposed transit. These joint findings will then be presented by the Commission to the people of the Bay Area in a series of public meetings throughout the region.

A coordinated system of transit, as we conceive it, would be a contributing service to the Bay Area's expanding economy and our objective is to propose a system that will continue to serve it for years to come. The survey which we have been working on since 1953 is probably the most extensive in scope and area ever undertaken. The people of the Bay Area are to be congratulated on their foresight in establishing the Rapid Transit Commission and charging them with the broad responsibility to investigate every aspect known to be related to traffic problems.

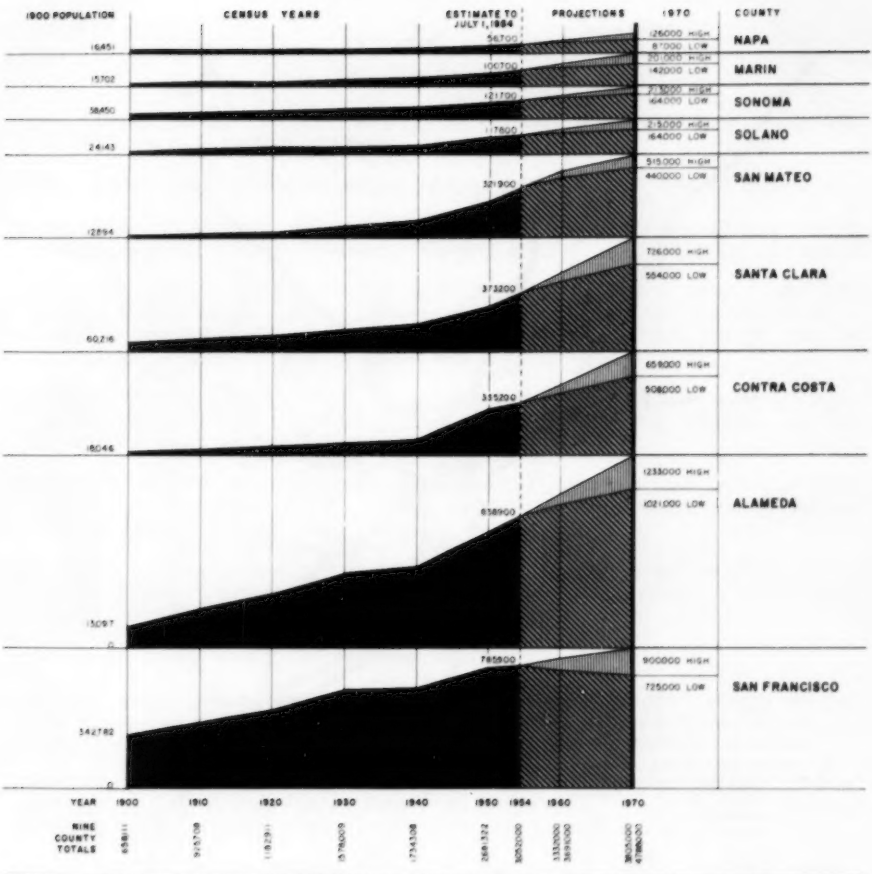
We anticipate that a system can be proposed that would not only furnish the only economically practical answer to provision of adequate traffic facilities, but that would also perform a very great service in encouraging the orderly expansion of the Bay Area as a unified metropolitan complex.



PEAK HOUR VOLUMES OF PASSENGERS AT SAN FRANCISCO - PENINSULA GATEWAY

(ACCORDING TO PURPOSE OF TRIP)

Figure 1



TOTAL POPULATION OF BAY AREA COUNTIES, 1900 - 1954,
AND PROBABLE HIGH AND LOW PROJECTION TO 1970

Figure 2

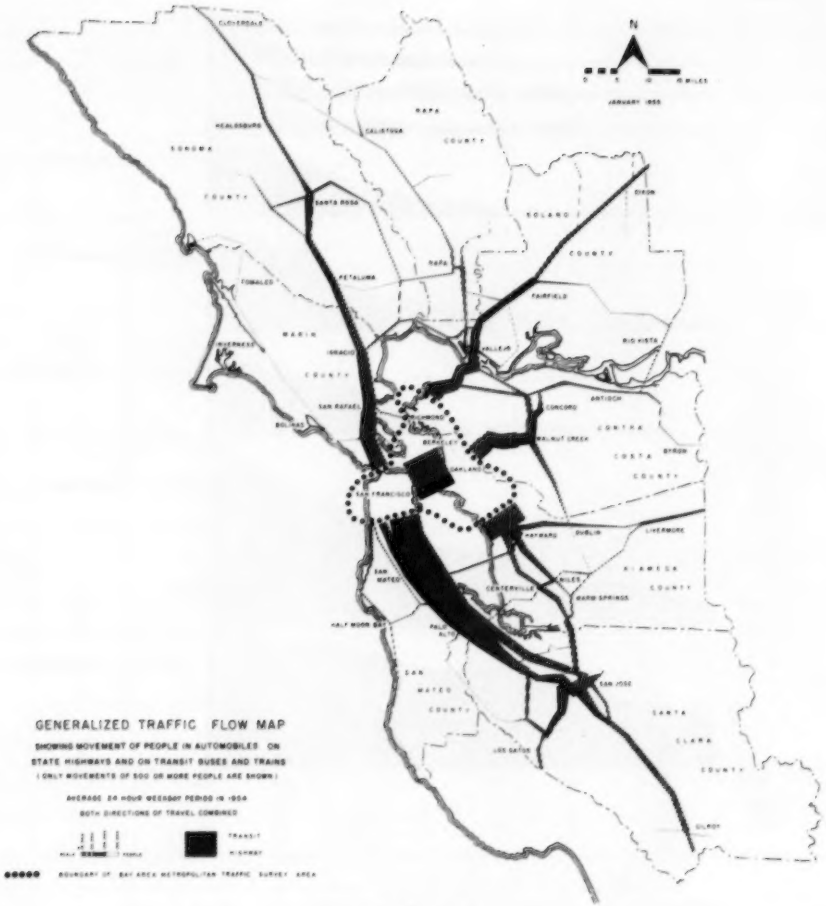

GENERALIZED TRAFFIC FLOW MAP
SHOWING MOVEMENT OF PEOPLE IN AUTOMOBILES ON STATE HIGHWAYS AND ON TRANSIT BUSES AND TRAINS
(ONLY MOVEMENTS OF 500 OR MORE PEOPLE ARE SHOWN)
AVERAGE 24 HOUR WEEKDAY PERIOD IN 1954
BOTH DIRECTIONS OF TRAVEL COMBINED
TRANSIT
HIGHWAY
BOUNDARY OF BAY AREA METROPOLITAN TRAFFIC SURVEY AREA
N
SAN FRANCISCO
OAKLAND
BERKELEY
SAN JOSE
SAN MATEO COUNTY
SANTA CLARA COUNTY
ALAMEDA COUNTY
CONTRA COSTA COUNTY
SOLANO COUNTY
NAPA COUNTY
SONOMA COUNTY
MARIN COUNTY

Figure 3

PROCEEDINGS-SEPARATES

The technical papers published in the past year are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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JUNE: 444(SM)[e], 445(SM)[e], 446(ST)[e], 447(ST)[e], 448(ST)[e], 449(ST)[e], 450(ST)[e], 451(ST)[e], 452(SA)[e], 453(SA)[e], 454(SA)[e], 455(SA)[e], 456(SM)[e].

JULY: 457(AT), 458(AT), 459(AT)[c], 460(IR), 461(IR), 462(IR), 463(IR)[c], 464(PO), 465(PO)[c].

AUGUST: 466(HY), 467(HY), 468(ST), 469(ST), 470(ST), 471(SA), 472(SA), 473(SA), 474(SA), 475(SM), 476(SM), 477(SM), 478(SM)[c], 479(HY)[c], 480(ST)[c], 481(SA)[c], 482(HY), 483(HY).

SEPTEMBER: 484(ST), 485(ST), 486(ST), 487(CP)[c], 488(ST)[c], 489(HY), 490(HY), 491(HY)[c], 492(SA), 493(SA), 494(SA), 495(SA), 496(SA), 497(SA), 498(SA), 499(HW), 500(HW), 501(HW)[c], 502(WW), 503(WW), 504(WW)[c], 505(CO), 506(CO)[c], 507(CP), 508(CP), 509(CP), 510(CP), 511(CP).

OCTOBER: 512(SM), 513(SM), 514(SM), 515(SM), 516(SM), 517(PO), 518(SM)[c], 519(IR), 520(IR), 521(IR), 522(IR)[c], 523(AT)[c], 524(SU), 525(SU)[c], 526(EM), 527(EM), 528(EM), 529(EM), 530(EM)[c], 531(EM), 532(EM)[c], 533(PO).

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DECEMBER: 558(ST), 559(ST), 560(ST), 561(ST), 562(ST), 563(ST)[c], 564(HY), 565(HY), 566(HY), 567(HY), 568(HY)[c], 569(SM), 570(SM), 571(SM), 572(SM)[c], 573(SM)[c], 574(SU), 575(SU), 576(SU), 577(SU), 578(HY), 579(ST), 580(SU), 581(SU), 582(Index).

VOLUME 81 (1955)

JANUARY: 583(ST), 584(ST), 585(ST), 586(ST), 587(ST), 588(ST), 589(ST)[c], 590(SA), 591(SA), 592(SA), 593(SA), 594(SA), 595(SA)[c], 596(HW), 597(HW), 598(HW)[c], 599(CP), 600(CP), 601(CP), 602(CP), 603(CP), 604(EM), 605(EM), 606(EM)[c], 607(EM).

FEBRUARY: 608(WW), 609(WW), 610(WW), 611(WW), 612(WW), 613(WW), 614(WW), 615(WW), 616(WW), 617(IR), 618(IR), 619(IR), 620(IR), 621(IR)[c], 622(IR), 623(IR), 624(HY)[c], 625(HY), 626(HY), 627(HY), 628(HY), 629(HY), 630(HY), 631(HY), 632(CO), 633(CO).

MARCH: 634(PO), 635(PO), 636(PO), 637(PO), 638(PO), 639(PO), 640(PO), 641(PO)[c], 642(SA), 643(SA), 644(SA), 645(SA), 646(SA), 647(SA)[c], 648(ST), 649(ST), 650(ST), 651(ST), 652(ST), 653(ST), 654(ST)[c], 655(SA), 656(SM)[c], 657(SM)[c], 658(SM)[c].

APRIL: 659(ST), 660(ST), 661(ST)[c], 662(ST), 663(ST), 664(ST)[c], 665(HY)[c], 666(HY), 667(HY), 668(HY), 669(HY), 670(EM), 671(EM), 672(EM), 673(EM), 674(EM), 675(EM), 676(EM), 677(EM), 678(HY).

MAY: 679(ST), 680(ST), 681(ST), 682(ST)[c], 683(ST), 684(ST), 685(SA), 686(SA), 687(SA), 688(SA), 689(SA)[c], 690(EM), 691(EM), 692(EM), 693(EM), 694(EM), 695(EM), 696(PO), 697(PO), 698(SA), 699(PO)[c], 700(PO), 701(ST)[c].

JUNE: 702(HW), 703(HW), 704(HW)[c], 705(IR), 706(IR), 707(IR), 708(IR), 709(HY)[c], 710(CP), 711(CP), 712(CP), 713(CP)[c], 714(HY), 715(HY), 716(HY), 717(HY), 718(SM)[c], 719(HY)[c], 720(AT), 721(AT), 722(SU), 723(WW), 724(WW), 725(WW), 726(WW)[c], 727(WW), 728(IR), 729(IR), 730(SU)[c], 731(SU).

c. Discussion of several papers, grouped by Divisions.

e. Presented at the Atlantic City (N.J.) Convention in June, 1954.

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